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SMALL AREA HIGHWAY PROGRAM

Progress Report
to the
Montana State Highway Commission
for
Season Ending September 30, 1958

By

F. C. Boner

U. S. GEOLOGICAL SURVEY
408 FEDERAL BUILDING
HELENA, MONTANA
MARCH 1959

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SMALL AREA HIGHWAY PROGRAM

Progress Report to the Montana State Highway Commission
for
Season Ending September 30, 1958

Introduction

This progress report is the fourth to be prepared for the Montana State Highway Commission under the provisions of annual cooperative agreements. It covers the water year October 1, 1957 to September 30, 1958. The first interim report covered the fiscal year July 1, 1955 to June 30, 1956. By mutual consent of the Montana State Highway Commission and the U. S. Geological Survey, the period covered in the annual progress reports was changed in 1956 from a fiscal year basis to a water year basis. Therefore, the second progress report covered the period July 1 to September 30, 1956 and the third progress report covered the water year October 1, 1956 to September 30, 1957.

An open-file report entitled "Floods in Eastern Montana, Magnitude and Frequency" by V. K. Berwick was furnished the Montana State Highway Commission in May 1958. This report presented a method of determining the magnitude and frequency of expected floods applicable for drainage areas of 100 to 3,000 square miles in most of eastern Montana. It superseded a provisional study entitled "Floods in Eastern Montana" which was furnished December 2, 1957.

Mr. L. W. Hargrove, hydrologist, Montana State Highway Commission, has been kept informed of all preliminary studies and has been furnished

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information on outstanding floods and other flow data upon request.

The collection of data continued to be the most important activity during the water year. The results of the past water year are summarized in this report.

Purpose of the Program

The purpose of the six-year program, initiated in 1955, is to collect peak flow data on streams of small drainage areas for a magnitude and frequency study. The resulting study will be useful in the determination of the flood expectancy for drainage basins of various sizes and types for use in designing adequate drainage structures. In order to obtain the necessary peak flow data, partial-record or crest-stage gage stations are maintained rather than the more expensive complete-record type of station.

A secondary purpose is to currently provide the Commission and its employees with the data collected and the results of any interim studies.

Station Network

The original network of stations consisted of 39 partial-record stations and 8 supplemental long-term stations located in 10 principal areas. Because of several discontinuances and changes in classification during the first two years of operation of the program, there were 40 partial-record and 4 supplemental stations in operation at the end of

the 1957 water year.

During the 1958 water year, two new partial-record stations were established, namely, Redwater Creek tributary near Brockway and Redwater Creek at Brockway. A complete-record station was constructed at Box Elder Creek near Winnett under a cooperative program with the Montana State Engineer. As the desired data will be available through this arrangement, funds of the Commission are no longer used in its support. Therefore, at the end of the 1958 water year there were 41 partial-record and 4 supplemental stations being financed under the highway program. A complete list of these stations may be found in table 1. The location of the stations and areas are shown in figure 1.

Monthly weather reports were made during the season by 14 unpaid observers. These reports contain information on the amount and duration of rainstorms, as well as snow accumulation and ground conditions during winter months.

The data collected at the short-term partial-record stations will be correlated with long-term complete-record stations when the final flood-frequency analysis is made. Unless an unusual sequence of drought years is experienced in the six-year program, it will be possible to develop a short partial duration series of floods, at least in the lower range. Graphical comparison of such discharges at a short-term station with the corresponding discharges for the same period at a station with a long record, where the mean annual flood is known, would permit estimates of the mean annual flood at the short-term station. After the

Table 1.--List of partial-record and supplemental stations

A. Partial-record stations financed by Montana State Highway Commission

Area	Station Name 1/	
	Present	Former
Great Falls	Sun River tributary near Great Falls	Cascade No. 1 near Great Falls
	Marias River tributary No. 1 near Loma	Chouteau No. 1 near Loma
	Marias River tributary No. 2 near Loma	Chouteau No. 2 near Loma
Harlowton	Antelope Creek tributary No. 1 (site No. 1) near Harlowton	Wheatland No. 1 near Harlowton
	Antelope Creek tributary No. 1 (site No. 2) near Harlowton	Wheatland No. 2 near Harlowton
	Antelope Creek tributary No. 2 near Harlowton	Wheatland No. 3 near Harlowton
	Antelope Creek at Harlowton	Same
Winnett	Box Elder Creek tributary near Winnett	Petroleum No. 1 near Winnett
	Box Elder Creek tributary near Cat Creek	Petroleum No. 2 near Winnett
	E. F. Box Elder Creek tributary near Cat Creek	Petroleum No. 3 near Winnett
Malta	Black Coulee near Malta	Same
	Alkali Creek near Malta	Same
	Disjardin Coulee near Malta	Same
	S. F. Taylor Creek near Malta	Same
Wolf Point	W. F. Wolf Creek near Lustre	Same
	E. F. Wolf Creek near Lustre	Same
	Wolf Creek tributary No. 1 near Wolf Point	Roosevelt No. 1 near Wolf Point
	Wolf Creek tributary No. 2 near Wolf Point	Roosevelt No. 2 near Wolf Point
Plentywood	Box Elder Creek near Plentywood	Same
	Box Elder Creek at damsite, near Plentywood	Same
	Spring Creek near Plentywood	Same
	Spring Creek at highway 16, near Plentywood	Same

Table 1.--List of partial-record and supplemental stations--Continued

A. Partial-record stations financed by Montana State Highway Commission--Continued

Area	Station Name 1/	
	Present	Former
Circle	E. F. Duck Creek near Brockway	Same
	Duck Creek near Brockway	Same
	Redwater Creek at Brockway	Same
	Tusler Creek near Brockway	Same
	Tusler Creek tributary near Brockway	McCone No. 1 near Brockway
	Redwater Creek tributary near Brockway	McCone No. 2 near Brockway
	S. F. Dry Ash Creek near Circle	Same
	McCune Creek near Circle	Same
Billings	Wets Creek near Billings	Same
	West Buckeye Creek near Billings	Yellowstone No. 1 near Billings
	Pryor Creek near Billings	Same
Broadus	Basin Creek tributary near Volborg	Custer No. 1 near Volborg
	Basin Creek near Volborg	Same
	Sand Creek near Broadus	Same
	North Creek near Alzada	Same
	Wolf Creek near Hammond	Same
Wibaux	Krug Creek tributary near Wibaux	Wibaux No. 1 near Wibaux
	Griffith Creek near Glendive	Same
	Spring Creek near Wibaux	Same

Table 1.-- List of partial-record and supplemental stations--Continued

B. Supplemental stations financed by Montana State Highway Commission

Area	Station Name 1/	
	Present	Former
Great Falls	Big Sandy Creek near Assinniboine	Same
Winnett	McDonald Creek at Winnett	Same
Plentywood	Big Muddy Creek at Plentywood	Same
Broadus	Rosebud Creek near Forsyth	Same
C. Partial-record stations financed by Montana State Engineer		
Jordan	Second Creek tributary No. 1 near Jordan	Garfield No. 1 near Jordan
	Second Creek tributary No. 2 near Jordan	Garfield No. 2 near Jordan
	Second Creek tributary No. 3 near Jordan	Garfield No. 3 near Jordan
Glasgow	Lime Creek tributary near Vandalia	Valley No. 1 near Vandalia
	Milk River tributary near Glasgow	Valley No. 2 near Glasgow
Intake	Linden Creek at Intake	Same
	Indian Creek at Intake	Same
	War Dance Creek near Intake	Same
Miscellaneous	Currant Creek near Roundup	Same
	Cat Creek near Cat Creek	Same
	Little Dry Creek near Van Norman	Same
	Little Porcupine Creek near Forsyth	Same
	Spring Creek near Decker	Same
	Willow Creek near Alzada	Same

1/ The names of stations on unnamed streams have been changed to comply with the new naming system used by the U. S. Geological Survey.

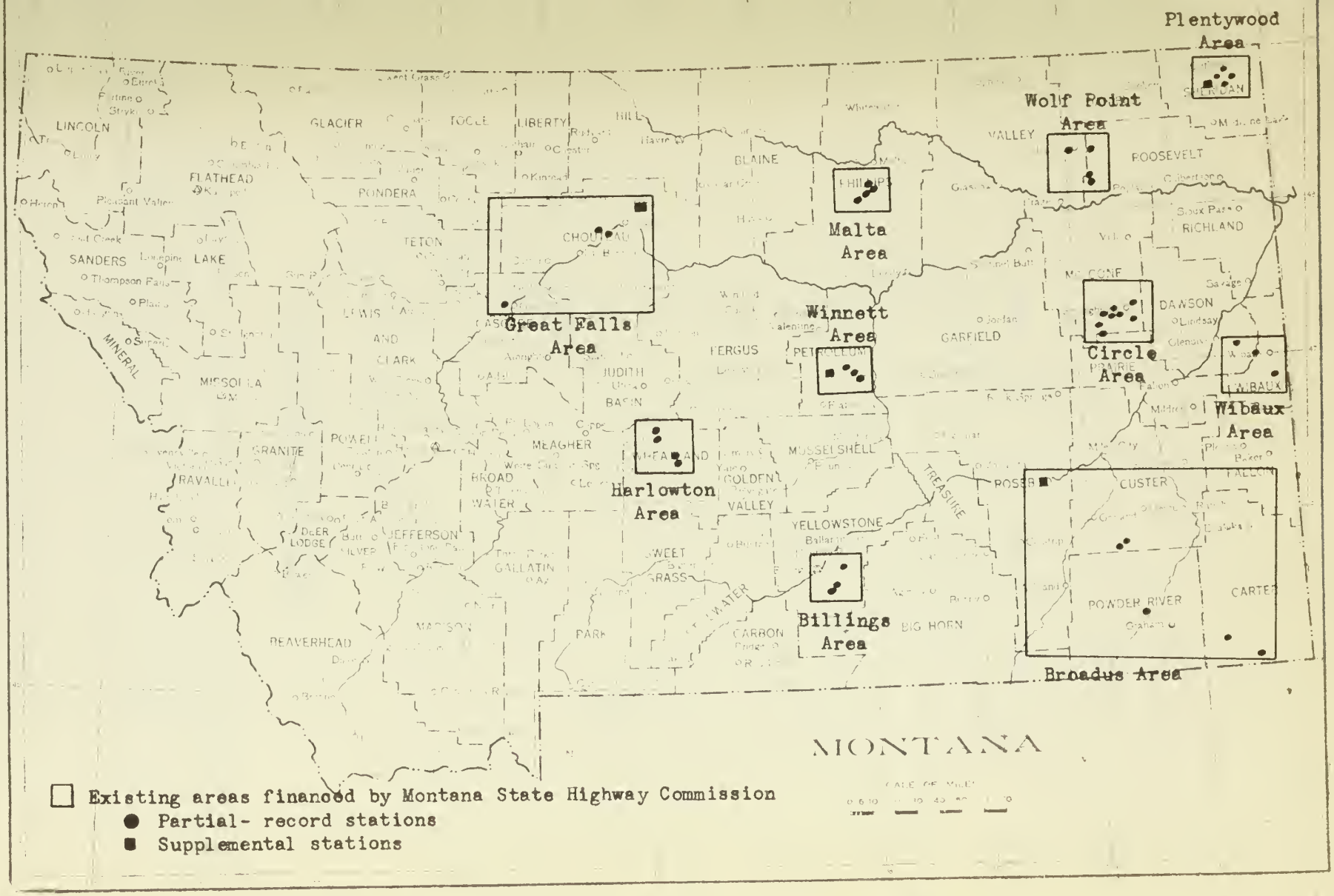

Figure 1.--Map showing location of areas and partial-record stations.

mean annual flood is determined, discharges of the rarer floods can be estimated from a regional flood-frequency graph. Continuity of both the short-term and long-term records is therefore essential. No regular gaging stations having probable value in the study have been discontinued. In some cases it has been possible to transfer financial responsibility to other programs of the U. S. Geological Survey.

Under a cooperative agreement with the Montana State Engineer, the U. S. Geological Survey established three complete-record stations on intermittent streams in northeastern Montana, namely, Sand Creek near Jordon, Lime Creek near Tampico, and Burns Creek near Savage. Partial-record stations were also established in the vicinity of each of the complete-record stations. Also, 6 partial-record stations were established in eastern Montana at which both high flow and low flow records are being collected. A list of these stations is shown in table 1. Figure 2 shows the location of all of these stations.

Data collected at the partial-record stations maintained in cooperation with the Montana State Engineer are not tabulated in this progress report. Information collected at these stations will be considered in the final magnitude and frequency study.

Progress During the Season

The collection of data continued to be the most important phase of the program during the water year. A total of 386 visits were made at the partial-record stations, during which 102 high-water marks were

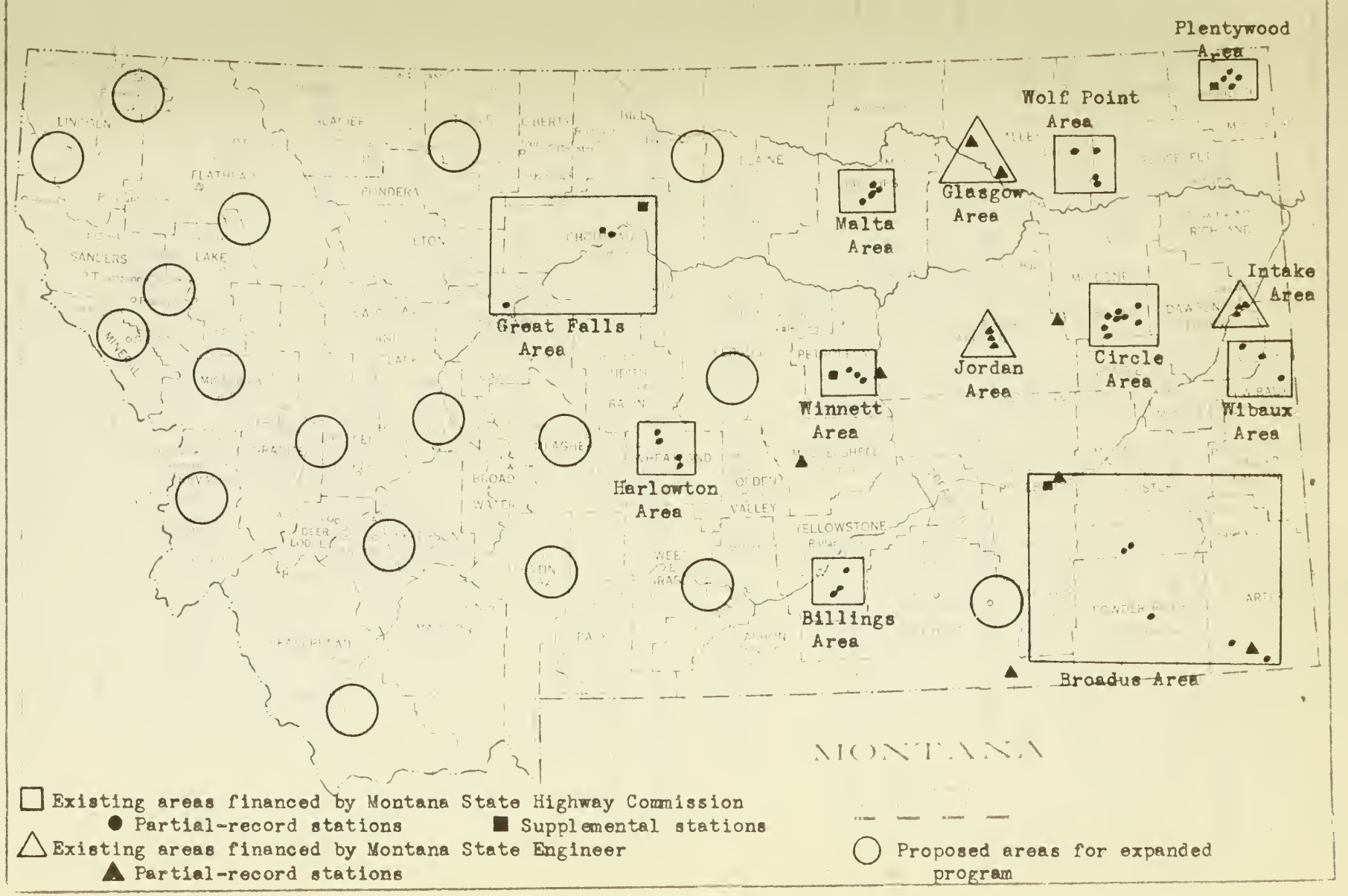

Figure 2.--Map showing existing and proposed areas and existing partial-record stations

found. Determinations of flow consisted of 10 estimates, 6 current-meter measurements, and 6 indirect measurements. The measurements were used in developing 6 new rating curves, making a total of 25 partial-record stations which have rating curves. All of the supplemental stations have rating curves. A tabulation of the annual maximum discharge at the rated partial-record stations and supplemental stations is shown in table 2 for the period of operation commencing in 1955. One copy of Appendix A, which lists the observations of discharge at the individual stations, has been furnished to Mr. L. W. Hargrove. A brief summary of Appendix A is shown below.

Summary of Progress and Observations of Peak Flow

Great Falls area.--Three partial-record stations and one supplemental station in operation. One partial-record station rated on basis of one current-meter measurement and one indirect measurement. Two partial-record stations remain un-rated.

Number of high-water marks at rated partial-record stations - - - 6

Number of high-water marks at non-rated stations - - - - - - - - - 5

Number of visits to partial-record stations - - - - - - - - - - - -25

Harlowton area.--Four partial-record stations in operation of which two are not rated. Two of the stations were rated previously.

Number of high-water marks at rated stations - - - - - - - - - - - 2

Number of high-water marks at non-rated stations - - - - - - - - - 1

Number of visits to stations - 44

Table 2.--Maximum annual peak discharges at rated stations.

Station	Drainage area	Date established	Maximum discharge previously known		Water year 1955		1956		1957		1958	
			Date	Discharge in cfs	Date	Discharge in cfs	Date	Discharge in cfs	Date	Discharge in cfs	Date	Discharge in cfs
Sun River tributary near Great Falls	21.1	8-16-55	--	--	--	--	Mar. 20	1	June 16	0.1	July 3	156
Big Sandy Creek near Assinniboine	2,000	4-9-55	4-3-52	5,570	Apr. 11	698	Mar. 30	a 550	Feb. 28	a 250	Mar. 28	a 500
Antelope Creek tributary No. 1 (site No. 2) near Harlowton	2.8	7-12-55	--	--	--	--	Mar. 17	207	June 16	188	May 23	17
Antelope Creek at Harlowton	73	7-12-55	6-17-50	24,400	June 26	591	June 15	800	June 21	380	--	< 35
McDonald Creek at Winnett	350	2-5-53	5-16-42	900	Apr. 11	241	Aug. 3	88	Mar. 19	67	July 19	150
Box Elder Creek tributary near Winnett	16.2	7-14-55	--	--	Aug. 23	132	June 18	123	Feb. 28	27	July 31	193
Box Elder Creek tributary near Cat Creek	2.32	7-14-55	--	--	Aug. 23	385	June 18	126	Aug. 30	36	July 19	72
E. F. Box Elder Creek tributary near Cat Creek	0.81	5-27-55	--	--	Aug. 23	159	June 18	32	Aug. 30	44	July 31	122
Disjardin Coulee near Malta	3.5	7-26-55	--	--	--	--	Aug. 5	160	Mar. 19	22	--	0
East Fork Duck Creek near Brockway	12.4	6-13-55	--	--	July 12	106	Mar. 2	60	July 14	352	July 21	8
Duck Creek near Brockway	52.5	5-21-57	--	--	--	--	--	--	July 14	640	July 3	135
Tusler Creek near Brockway	90.2	10-12-56	--	--	--	--	--	--	Feb. 27	200	July 21	14
Redwater Creek tributary near Brockway	0.29	1-15-58	7-14-57	83	--	--	--	--	--	--	--	0
South Fork Dry Ash Creek near Circle	5.74	6-13-55	--	--	July 12	56	Mar. 1	17	Feb.26	52	June 3	3
McCune Creek near Circle	28	6-13-55	--	--	July 12	128	Mar. 20	52	July 14	175	June 3	6
Big Muddy Creek at Plentywood	848	6-10-55	6-30-53	8,000	--	< 210	Mar. 22	a 300	July 16	413	Mar. 29	1,630
Box Elder Creek near Plentywood	9.4	6-10-55	--	--	--	0	--	0	July 23	328	Mar. 30	22
Box Elder Creek at damsite, near Plentywood	19.9	6-23-55	6-30-53	6,530	Mar. 29	890	--	.0	July 23	1,600	Mar. 30	210

Table 2.--Maximum annual peak discharges at rated stations--Continued.

	Drainage area	Date established	Maximum discharge previously known		Water year							
					1955		1956		1957		1958	
			Date	Discharge in cfs	Date	Discharge in cfs	Date	Discharge in cfs	Date	Discharge in cfs	Date	Discharge in cfs
Spring Creek near Plentywood	7.05	6-23-55	--	--	July 7	5	--	0	July 23	76	Mar. 30	25
Spring Creek at highway 16, near Plentywood	16.9	6-23-55	--	--	--	0	Apr. 3	4	July 23	540	Mar. 30	230
Wets Creek near Billings	9.14	5-26-55	--	--	July 1	3	Feb. 22	65	June 8	62	July 2	14
West Buckeye Creek near Billings	2.58	5-26-55	--	--	Aug. 25	17	May 29	92	May 12	185	July 2	83
Pryor Creek near Billings	425	5-26-55	5-14-52	1,500	June 16	286	Feb. 22	a 800	June 8	825	Feb. 20	262
Rosebud Creek near Forsyth	1,370	7-15-55	5-30-53	596	--	< 50	Mar. --	a 350	June 17	342	Mar. --	b
Basin Creek tributary near Volborg	0.70	7-23-55	--	--	July 29	20	--	0	--	0	July 2	390
Basin Creek near Volborg	9.50	7-23-55	--	--	July 29	20	Aug. 27	800	Apr. 24	300	July 2	810
Sand Creek near Broadus	9.6	7-22-55	--	--	--	0	Mar. 16	19	Aug. 28	15	June 7	93
Wolf Creek near Hammond	9.09	7-22-55	--	--	July 11	298	Mar. 22	210	Aug. 29	365	June 3	549
North Creek near Alzada	0.68	7-21-55	--	--	--	0	July 2	276	Aug. 28	276	June 3	417

a - Approximate figure
b - Discharge unknown

Winnett area.--At the close of the water year three partial-record stations and one supplemental station were in operation. All of the stations have rating curves.

Number of high-water marks at partial-record stations - - - - 4

Number of visits to partial-record stations - - - - - - - - -29

Malta area.--Four partial-record stations in operation of which one has been previously rated.

Number of high-water marks at rated stations - - - - - - - - 0

Number of high-water marks at non-rated stations - - - - - - 5

Number of visits to stations - - - - - - - - - - - - - - - - - 46

Wolf Point area.--Four partial-record stations in operation. No ratings have been developed due to the lack of significant flow.

Number of high-water marks at stations - - - - - - - - - - - - 1

Number of visits to stations - - - - - - - - - - - - - - - - - 37

Circle area.--Eight partial-record stations were in operation at the end of the water year. New ratings were developed at two stations making a total of six stations with rating curves.

Number of high-water marks at rated stations - - - - - - - - 8

Number of high-water marks at non-rated stations - - - - - - 2

Number of visits to stations - - - - - - - - - - - - - - - - - 71

Plentywood area.--Four partial-record stations and one supplemental station in operation. All stations have ratings which were developed previously.

Number of high-water marks at partial-record stations - - - -14

Number of visits to partial-record stations - - - - - - - - - - 34

Billings area.--All of the three partial-record stations have previously developed ratings.

Number of high-water marks at stations - - - - - - - - - - - - - 17

Number of visits to stations - - - - - - - - - - - - - - - - - - 21

Broadus area.--Five partial-record stations and one supplemental station in operation. All stations are now rated, four previously rated and two new ratings.

Number of high-water marks at partial-record stations - - - - 32

Number of visits to partial-record stations - - - - - - - - - 41

Wibaux area.--Three partial-record stations in operation. No ratings were developed due to the lack of significant flow.

Number of high-water marks at stations - - - - - - - - - - - - 6

Number of visits to stations - - - - - - - - - - - - - - - - - - 38

Tabulation of Field Work:

High-water marks at partial-record stations - - - - - - - -		102
Visits to partial-record stations - - - - - - - - - - - - -		386
Determinations of flow: Current-meter measurements - - - -		6
	Indirect measurements - - - -	6
	Estimates - - - - - - - - - -	10

The achievement of significant results from this program during the relatively short period of six years may be contingent upon the relation of the partial-record station data to the long-term records which were the basis for the open-file report on magnitude and fre-

quency. A trial study was undertaken to show how the data would be utilized. As the flood experience during the program has been limited and some stage-discharge ratings have not been developed, results are not meaningful. Mr. L. W. Hargrove examined the study and felt that it was not at variance with the criteria currently used in the selection of design flow.

As a part of the regular stream-gaging program of the U. S. Geological Survey, miscellaneous measurements of peak flow are made at points where significant damage is reported or the peak discharge may be hydrologically significant. The resources of the U. S. Geological Survey do not permit coverage of all reported events, and it is acknowledged that many may escape attention. The four discharge measurements made during the past water year illustrate the randomness of intense precipitation during the thunderstorm season and are listed in table 3.

Plans for the 1959 Season

An expansion of the program to provide for collection of peak-flow data from selected small drainage areas throughout Montana was made effective by a revised cooperative agreement dated November 1, 1958. Under this agreement the U. S. Geological Survey will be reimbursed in full for all appropriate costs. It is understood the Montana Highway Commission may utilize Planning Survey funds which are federally matched by the U. S. Bureau of Public Roads in a ratio that is more favorable to the Commission than the equal match which had prevailed. This enlarged

Table 3.--Discharge measurements made at points other than gaging stations.

Stream	Tributary to	Location	Drainage Area in sq mi	Date of peak flow	Discharge in cfs
		Prickly Pear Creek basin			
Leggerini Creek	Tenmile Creek	SE¼NW¼ sec. 31, T. 10 N., R. 4 W., a quarter of a mile upstream from mouth and 5 miles west of Helena	1.37	June 8, 1958	290
Spring Gulch	Sevenmile Creek	SW¼SW¼ sec. 36, T. 11 N., R. 5 W., about a quarter of a mile upstream from mouth, 2 miles west of Birdseye, and about 8 miles northwest of Helena	0.42	July 7, 1958	449
		Rock Creek basin			
Unnamed Creek	Spring Creek	SE¼ sec. 13, T. 15 N., R. 4 W., about a quarter of a mile upstream from mouth, 1.2 miles north of bridge on Rock Creek, and 3½ miles north of Wolf Creek	0.69	June 6, 1958	1,320
		Musselshell River basin			
Unnamed Creek	Unnamed Creek *	NE¼ sec. 6, T. 6 N., R. 20 E., about 100 ft upstream from mouth and half a mile north of State Highway 6 at Ryegate	0.082	July 18, 1958	352

* This stream flows through the town of Ryegate. Two long-time residents said this was the fourth and worst flood of the past 30 years. The last previous flood was in 1942.

program will encompass the previous program and provide for about 60 additional partial-record stations. It is visualized that data collection for the new stations should extend over a minimum period of six years to yield significant results. At the completion of this new six-year period, a report on the magnitude and frequency of floods on a state-wide basis is planned. Previous understandings regarding the analysis of the data from the original group of stations at the conclusion of the original six-year period are acknowledged.

The collection of peak flow data at the original sites will continue. The location of the additional partial-record sites has not yet been determined as field reconnaissance has not been practical since completion and approval of the revised agreement. On the basis of general observations, it is believed that 3 to 5 gages will be installed within each of the circled areas shown in figure 2. The completion of installations of the 60 additional sites is scheduled for September 1959.